ASTRONAUTS' BASIC REQUIREMENTS FOR PERSONAL HYGIENE MATERIALS

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Before scientifically based measures for hygienic care of human skin can be undertaken during long space flights, and before the study of the action of unusual conditions of life on board the spacecraft on the human body as a whole and on the skin in particular can be completed, all the basic physiological, biochemical, and microbiological constants of the human skin must be known. /420

Materials and methods of skin toilet must be effective both under the conditions of a changed gravitational field (allowing for changes in the behavior of fluids), and also when water consumption is limited.

Realizing the important positive role of the human symbiotic microflora, this factor must be taken into account when materials and methods of personal hygiene are devised and it must be correctly reflected in the basic requirements for these materials. Finally, having regard to the prolonged and frequent exposure to personal hygiene materials, they must not be toxic either when applied to the skin or when their vapors and aerosols enter the human body. /421

Data in the literature and our own observations indicate that these problems are not only complex, but are also incompletely solved and their study is dependent not so much on the organization and performance of special experiments as on a correct understanding of the essence of these problems.

To this must be added the special complexity of the epidemiologic aspect of personal hygiene of astronauts during long flights. Remembering that the human bacterial population comprises thousands of species of microorganisms, some useful, others harmful, the complexity of interaction of the microflora will be obvious even for a crew consisting of two persons.

Not only do we not know all the mechanisms and conditions for interaction of the autoflora of different individuals, but we also have no effective methods of stabilization or disinfection of pathogenic or conditionally pathogenic microflora directly on the human body. With this level of knowledge concerning the various conditions of prolonged human isolation it is extremely difficult both to solve the problems of prophylactic cleansing and toilet of the human skin and also to guarantee the epidemiologic well-being of crew members during long-duration space flights.

The skin, as is well known, is an important intermediary between the external environment and the organism as a whole. One of its essential functions is to protect the human organism from external influences (physical, chemical and biological).

The protective role of the skin against bacterial contamination is particularly important, not merely as a mechanical barrier (the stratum corneum), but also and, to a greater degree, by virtue of the biochemical reactions taking place on the skin surface.

We refer to the change in pH towards the acid side found on the surface layer of the skin (pH 3-5), largely attributable to the accumulation of secretions of the sebaceous glands on the skin and to chemical processes taking place in them under the influence of many different factors during prolonged isolation of the human subjects in a small closed room and prohibition of hygienic procedures. It is of course essential to point out that the importance of the sebaceous function is obvious from the existence of its central regulation (by the pituitary and sex glands). In experiments of long duration, A.M. Finogenov discovered a definite relationship between the quantity of sebum cutaneum on the human skin (layer of saturation), the pH of the skin surface and the number of bacterial cells present at a given moment on the skin. For example, in a subject with a layer of saturation of sebum cutaneum on the investigated areas of skin towards the end of a 30-day experiment amounting to 106 $\mu g/cm^2$ (pH 4.6) and 61 $\mu g/cm^2$ (pH 5.0), the relative number of bacterial colonies per cm^2 skin surface was (from data of L. N. Prokhorova) 3.4 and 19.7 respectively whereas for a subject with a saturation layer on these same areas of skin of 78 $\mu g/cm^2$ (pH 5.0) and 43 $\mu g/cm^2$ (pH 5.2), under the same conditions, the corresponding figures were 18.2 and 41.3. /422

Clearly fewer bacterial colonies were found on areas of skin with a higher concentration of sebum cutaneum, and vice versa. The at first glance paradoxical situation must now be considered that unrestricted washing of the skin, removing all products of the sebaceous and sweat glands, interferes with the protective function of the skin and cannot therefore be regarded as a rational hygienic measure.

Our investigations have shown that the dynamics of the bacterial population of the skin depend on other factors than the time of human isolation. Stabilization of the bacterial population of the skin arises primarily as a result of the accumulation of sebum cutaneum in the underclothing and on the skin surface and on the changes taking place in its chemical composition. To this it must be added that the structure of the material and the nature of the fiber used in making the underclothing undoubtedly play an important role in this process, for they influence the properties of the material to absorb the secretions of the sebaceous and sweat glands. It would be wrong in general to deny the benefit to be obtained by washing the human skin, although we must adopt a discriminating approach to this habitual procedure and emphatically reject the simple doctrine of the textbooks of personal hygiene: the more thoroughly the skin is freed from secretions of the sebaceous and sweat glands the more active its protective function. This statement, of course, is untrue not only for conditions of life and activity of astronauts, but also for many other terrestrial occupations.

Another familiar point must be added here, namely, that if there is a deficiency of lipids on the skin surface, not only the local thermoregulation and metabolism may be disturbed, but also the basic protective functions of the skin against harmful external factors.

In recent years, through the efforts of Soviet hygienists, chemists, dermatologists and microbiologists, some of the personal hygiene problems reflected in the main requirements of materials for skin hygiene of astronauts during long-duration space flights have been solved.

Ideally, the personal hygiene materials of astronauts should possess selective cleansing properties relative to external contaminants and, at the same time, they should be neutral toward biologically active substances occurring on the skin and in its surface layer. It is most important that personal hygiene materials for use by astronauts should contain certain biologically active substances (vitamins, hormones, enzymes). As regards the bactericidal action of personal hygiene materials, it must be stressed once again that the autoflora plays a highly positive role in human vital activity, for it possesses immunizing, enzyme-forming and vitamin-producing action and also antagonistic properties against certain external microorganisms. It can therefore be considered on good grounds that personal hygiene materials should possess bacteriostatic and not bactericidal activity. With respect to bactericidal properties, personal hygiene materials should possess selective action only aginst pathogenic and conditionally pathogenic microorganisms causing external contamination. /423

The general recommendations given below are preliminary and they by no means claim to be exhaustive. In the first place, the purpose of personal hygiene materials for use by astronauts must be stipulated.

Personal hygiene materials for astronauts are intended for systematic use during flight in order to maintain the physiological constants of the human skin at a satisfactory level, for cleansing the skin and freeing it from external contaminants and breakdown products of the secretion of the sebaceous and sweat glands, and also to maintain the astronaut's psychological optimum.

Bearing in mind the many different purposes for which personal hygiene materials are used by astronauts, these materials must satisfy the following demands:

1. Personal hygiene materials must be capable of cleansing the astronauts' skin to remove contamination by decomposition products of the secretions of the sebaceous and sweat glands, desquamated keratin scales of the epidermis, dust particles of various types, and other external contaminants.

2. These materials must promote normal skin function and maintain its optimal for attainable physico-mechanical properties and biochemical and physiological constants.

3. Astronauts' personal hygiene material must possess bacteriostatic activity against the autoflora.

4. During systematic and prolonged use of personal hygiene materials, they must not produce diseases of the skin, unpleasant subjective sensation, changes in the color of the skin, pigmented spots, hyperkeratosis, or destruction or desquamation of the epidermis. They must not sensitize the skin to ultraviolet and ionizing radiation.

5. Personal hygiene materials must possess a marked freshening action /424
and have no odor. However, the use of very weak perfumes is permissible, in accordance with the individual preference of each astronaut. Perfumes simulating natural odors—of the forest, flowers, newly mown hay, the sea, and so on—are preferable.

6. Personal hygiene materials must not contain toxic or powerfully acting substances or volatile compounds capable of creating explosives or inflammable concentrations in the spacecraft cabin during use.

7. The constituents of personal hygiene materials must be completely compatible with the life-support systems operating on board the spacecraft and, should they enter the atmosphere of the cabin, they should be readily absorbed by the absorbents and filters used.

8. The raw and finished products used for personal hygiene materials must satisfy existing standards and technical conditions.

9. Personal hygiene materials must be prepared in a liquid or paste form and be kept in special tubes. These must bear labels indicating the rules for use of the particular material and its length of useful life.

10. Personal hygiene materials for astronauts must be prepared under sterile conditions, using minimal quantities of water in their formulas.

11. Utensils used for application of personal hygiene materials by astronauts must be compact in design, of minimal weight, and simple and reliable for use under conditions of weightlessness or abnormal gravitation.

12. The conditions of use and storage of these materials must correspond to the conditions for storage of liquid food products for consumption by the astronauts on board, which are packed in standard tubes.